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Geochemical Characterization and Depositional Environment Interpretation of Sediments from Field 'X', Greater Ughelli, Niger Delta

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ABSTRACT

This study presents a comprehensive geochemical characterization of ninety-five ditch cutting samples from Well-1 and Well-2 using X-ray Fluorescence (XRF) analysis. The primary focus was to determine the elemental composition and interpret the depositional environment. The major oxides present include SiO2 and Al2O3, indicating a dominance of silicates, primarily quartz and clays. The SiO2/Al2O3 ratios, predominantly around 3.5 to 4, suggest the presence of feldspathic and wacke sandstones, indicative of poor mineralogical maturity and sorting. High Fe2O3/K2O ratios imply an abundance of less stable minerals, characteristic of greywackes and lithic arenites. Elevated TiO2/Al2O3 ratios point to a mafic igneous or metamorphic provenance. These findings highlight a complex sedimentary history and a varied depositional environment, involving contributions from both sedimentary and igneous/metamorphic sources.

Keywords: XRF analysis, ditch cuttings, geochemical characterization, depositional environment, provenance analysis.

INTRODUCTION

The Niger Delta is a prime location for oil and gas exploration. Its extensive sedimentary records and intricate depositional contexts have been the subject of much geological and geochemical study (Doust & Omatsola, 1990; Nwachukwu & Chukwura, 1986). Geochemical characterization and the depositional setting can be better understood by examining Field "X" in the Greater Ughelli region of the Niger Delta. This is due to the fact that it contains several kinds of rocks and a large amount of hydrocarbon potential.

Conducting a comprehensive geochemical study of sediment samples from Field 'X' is the primary objective of this research. By doing so, we want to gain a better understanding of the depositional settings and processes that have molded this region. Verifying the accuracy of depositional models and estimating the field's hydrocarbon potential requires geochemical characterisation. The reason behind this is that it provides crucial information regarding the sediments' origin, mineralogy, and diagnostic history, as well as their age.

Ditch cuttings from two separate wells are analyzed for the presence of main and minor oxides using X-ray fluorescence (XRF) techniques (Well-1 and Well-2). We can determine the mineral compositions and elemental ratios that reveal the formation and movement of the parent rock and sediments through it by analyzing the levels of significant oxides such as SiO2, Al2O3, Fe2O3, and TiO2. Additional oxides may be discovered.

Identifying quartz-rich sandstones from clay-rich shales requires knowledge of the SiO2 to Al2O3 ratio. Not only does this ratio aid in sediment separation, but it also reveals the dynamic changes in sediment texture. The stability of a mineral can also be determined by looking at its Fe2O3 to K2O ratio. It would appear from this ratio that the rock-forming minerals are not as solid. One way to determine the sediments' origin is to look at their titanium dioxide to aluminum dioxide ratio (TiO2/Al2O3). We can determine if they originated from mafic or felsic rocks based on this.

It is feasible to reconstruct the depositional history of Field 'X' by collecting geochemical, sedimentological, and stratigraphic data from the region. Knowing the Niger Delta's depositional environment can help in improving exploration and production techniques, checking reservoir quality, and locating potential hydrocarbon traps (Short & Stauble, 1967).

The results of this study will contribute significantly to our knowledge of the geology of the Greater Ughelli area and to the continuing exploration and development efforts in the Niger Delta region. Because of the complexity of basins containing hydrocarbon deposits, geochemical analysis is crucial in sedimentary geology, as demonstrated in this work.

LITERATURE REVIEW

Conceptual Framework of the Niger Delta

Around the time of the Jurassic period's end, the Niger Delta clastic wedge formed. The aulacogen, a three-pronged structure for mending damaged limbs, was the culprit. The tectonic plates that comprise South America and Africa separated, giving rise to this system (Burke et al., 1972; Whiteman, 1982). In West Africa, a passive continental barrier is formed by the two bumps that run along the coasts of Cameroon and Nigeria. Because to some issues with the third arm, the Benue Trough was developed. Many depocenters who lived along the Atlantic coast of Africa also had an impact on the formation of the delta (Figure 2.1). Sediments discovered and dated in the Syn-rift area are the oldest. The Tertiary and Cretaceous epochs are responsible for the deposition of these deposits. The appearance of the Albian sediments is depicted here. Clastics and carbonates from the ocean floor, both at the syn-rift and marginal margins, are found deeper in the Earth's crust. Several instances of regression and transgression led to its formation (Doust and Omatsola, 1989). At this point, the Santonian basin inversion marked the beginning of the end of the Syn-rift period (Late Cretaceous). Once the continents began to drift apart, the Benue Trough began to sink once more due to the inundation of water. Midway during the Cretaceous epoch, the Niger Delta clastic wedge began to advance. Furthermore, it shifted away from its core as it passed through the triple junction, a rift in the continental crust. The Benue and Bida basins were formed when two rift arms that had previously failed forced the silt to the top. These ponds were subsequently connected to the major drainage systems. Sedimentation could be halted during the Late Cretaceous period due to invasions.

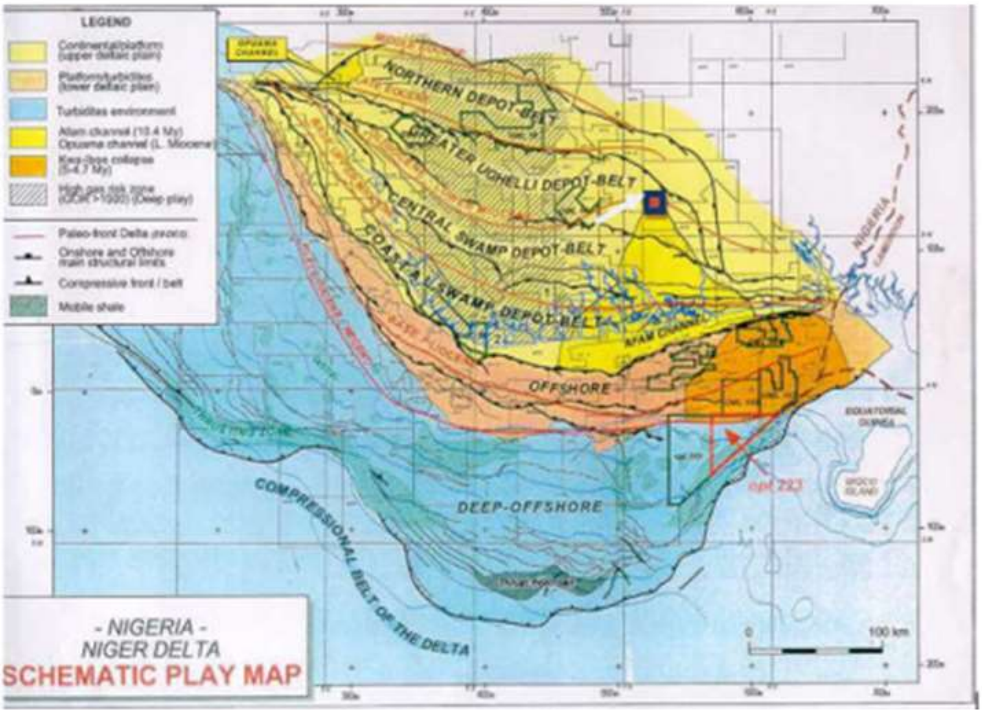


Figure 2.1: Section Map of Nigeria showing Depobelts that make up the Niger Delta Basin (modified from Nwozor *et al.,* 2012)

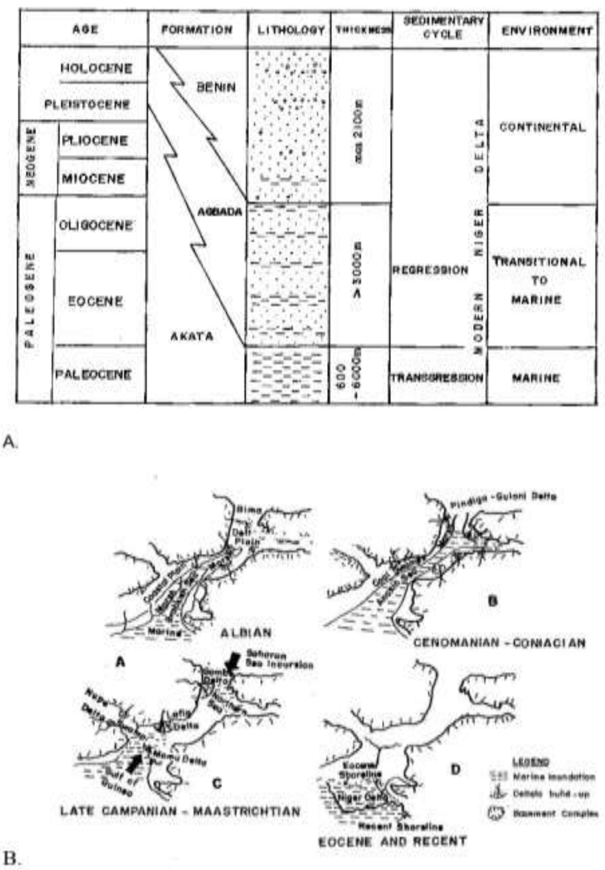


Figure 2.2: Niger Delta lithostratigraphy (A) Generalized lithostratigraphy of Niger Delta (from Nwangwu, 1990) (B) Cretaceous to Recent paleogeographic evolution of Nigerian rift and continental margin deltas (After Peters, 1978).

During the Tertiary period, a great deal of sediment was transported from the east and northwest by the Niger, Benue, and Cross Rivers. Much of the volcanic rock that washed up along the Cross and Benue rivers originated in the Miocene eruptions of the Cameroon volcanic zone, according to scientists. These were present in both rivers. The rapid movement of the clastic wedge from the Niger Delta into the Gulf of Guinea was caused by the continued sinking of the basement and the expansion of drainage zones. Both of these things have to be in place for this development to take place. Sedimentation since the Oligocene accelerated the rate of regression during the Eocene (Figure 2.2). Alterations to the Niger Delta's shape began in the early Paleocene, persisted until the early Eocene, and peaked in the Miocene. Evidence suggests this strategy has far-reaching consequences for the whole Niger Delta. The early coastal zones' deposit distribution was significantly impacted by the foundation's curved shape toward the sea (Doust and Omatsola, 1989). The initial one, which sank at the same speed as the Niger River, was clogged with silt. The smaller second began to operate in basins farther downstream of the Cross River from the Eocene into the early Oligocene, while the larger first began operations in basins more upstream. This happened when the coastlines expanded into the Olumbe-1 area (Short and Stauble, 1967). The Ihuo Embayment separates this depositional axis from the Niger Delta's main deposits. Following this, sediment from the Cross River and other adjacent waterways swiftly filled the Ihuo Embankment (Short and Stauble, 1967). The final stages of deposition were preceded by two distinct deposition periods in the east and west, which merged in the early to middle Miocene epoch. At the same time, the deposition procedure commenced. As a result of delta degradation in the late Miocene, the coastlines began to dip sharply into the basin. This occurred as a result of the delta's expansion. The loading mechanism became stronger as the rapidly expanding delta pushed the weak shales below it. Shale swells and diapiric walls disrupt the surrounding layers. Localized ground elevation is attributable to complex deformation patterns brought about by large-scale erosion episodes at the Niger Delta's front edge. These tragic occurrences partly paved the path for what is now known as the Niger Delta. The shelf is traversed by a number of deep canyons. These clay-filled gorges likely originated during a period of exceptionally low sea levels. The Qua Iboe, Opuama, and Afam Canyons are the most beloved by visitors due to their breathtaking beauty. There are three main depositional cycles in the Niger Delta's tertiary strata (Short and Stauble, 1967; Doust and Omatsola, 1990). Geology began with these two occurrences. Beginning with a maritime incursion in the mid-Cretaceous, they primarily included marine deposits. A massive invasion by sea occurred as a result of this in the Paleocene period. The formation of a "real" delta is demonstrated by this second cycle, which begins in the late Paleocene and concludes in the early Eocene. From the Paleocene to the early Eocene is when it begins. The shoreline of this delta is shaped like a crescent moon by the forces of the sea. While these sediments originate in the northern region from the Eocene period, they originate in the southern region from the Quaternary period (Doust and Omatsola, 1990). Large syn-sedimentary faults, according to Doust and Omatsola's 1990 article, divided the most recent cycle of deposits into six depobelts. Such depocenters are sometimes known as megaseries or depocenters in certain literary works. Sediment deposits were concentrated in already-crowded delta basins to create depobelts, which were formed by patterns of structural deformation that impeded material transport. The surrounding terrain gradually shifted toward the basin as it began to fill in around the deposit. This led to the funds being transferred to (Doust and Omatsola, 1990).

The flow of soft, severely compressed, and deeply buried marine shale has caused significant changes to the clastic wedge of the Niger Delta (Doust and Omatsola, 1989). The movement of the delta created these faults because they are formed during sedimentation. Numerous issues occurred simultaneously. The overall distribution of silt in the delta was altered by this. As the fault extended, the slopes along the edge of the continent became more precarious. The Niger Delta series consists of overpressured marine shales, which, as depth increases, cause faults to flatten out into a master detachment plane. This plane is the first in the series. In terms of localized structural complexity, there is a correlation between fault count and kind. Crestal faults and flanking faults are two examples of basic geological formations that can be explained by a single fault. The configuration of the listric fault and the varying stresses acting on deltaic sediments deposited on top of ductile shales led to the formation of hanging-wall rollover anticlines. Fault dips of widely varying depths and dome-shaped collapsing crests are two examples of the more complex structures. A variety of faults, each with its own rate of movement, can erode these formations.

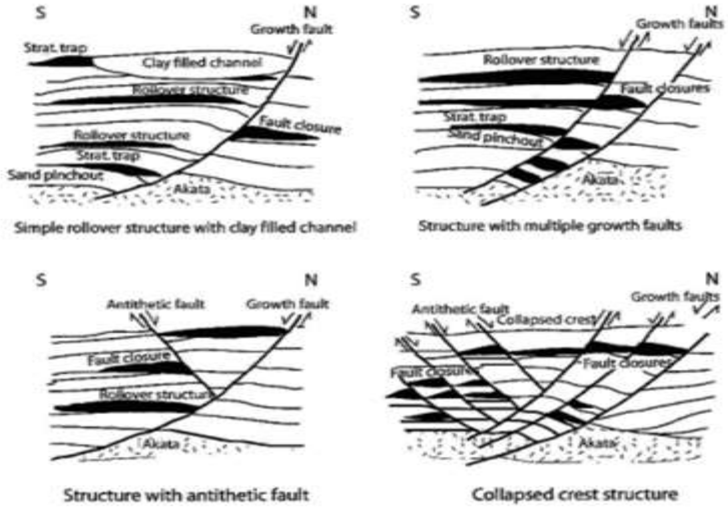

Simple rollover structure with clay filled channel
Structure with multiple growth faults
Structure with antithetic fault
Collapsed crest structure

Figure 2.3 shows the structure of the Niger Delta Oil field and related traps. (Adapted from Stacher, 1995 and Doust and Omatsola, 1990.)

Niger Delta Stratigraphy

Even though the largest oil firms in the Niger Delta Basin have conducted extensive studies on the stratigraphy of the clastic wedge for the purpose of oil exploration and production, they still own many of the stratigraphic schemes in the region. This remains true even after stratigraphic systems are documented. Research by Short and Stauble examines the Tertiary Niger Delta and the Lower Cretaceous epochs in which it was active (1967). There have been three investigations of the Niger Delta region's oil geology. Three separate study groups contributed articles to this volume: Tuttle et al. (1990), Doust and Omatsola (1978), and Evamy et al. (1978). (1978). (1978). (1994). (1999). This model of the Niger Delta hydrocarbon environment was created by Stacher (1995) using sequence stratigraphic methods. Allen and Oomkens documented the physiography, sedimentology, and depositional circumstances of the Niger Delta in a 1965 paper. (1965). (1974). The subsoil of the Niger Delta is composed of three distinct lithostratigraphic units. All three of these groups—Agbada, Benin, and Akata—form one cohesive unit. An illustration of this can be seen in Figure 2.4. The depositional zones in the Niger Delta shift toward the crystalline wedge and away from the clastic wedge as these strata age, according to their placement. Further south in Nigeria, you'll find geological units that are very comparable to those three formations (Table 2.1; Short and Stauble, 1967). A clastic wedge with an upward sloping plane was demonstrated by Short and Stauble in 1967 to have created the rocks. The rocks were discovered in a variety of aquatic habitats, including deltas and rivers. Volcanic rocks are also present on top of that (Weber and Daukoru, 1975; Weber, 1986). Approximately 80 kilometers to the east of Port Harcourt is the Akata 1 Well, which could contain the precise location of the Akata Formation (Short and Stauble, 1967). It was 1967, according to Stauble and Short. It was impossible for the Akata-01 well to access the deposit, despite its depth of 3,680 meters (11,121 ft) (3,680 meters). The thickest strata of deltaic sandstone comprise the formation, which reaches a height of 7,180 feet at its peak (7,180ft). About 21,000 feet of rock are believed to make up the majority of the clastic wedge (Doust and Omatsola, 1989). However, turbidite floods may occasionally cause sand streaks to appear. On the surface, you can see mostly silt and dark gray shale (Doust and Omatsola, 1989). Many believe that the microfauna collection is primarily composed of planktonic foraminifera found in the ocean. Foraminifera are evidence of the formation of a shallow marine shelf (Doust and Omatsola, 1990). The findings from Doust and Omatsola's study (1989).

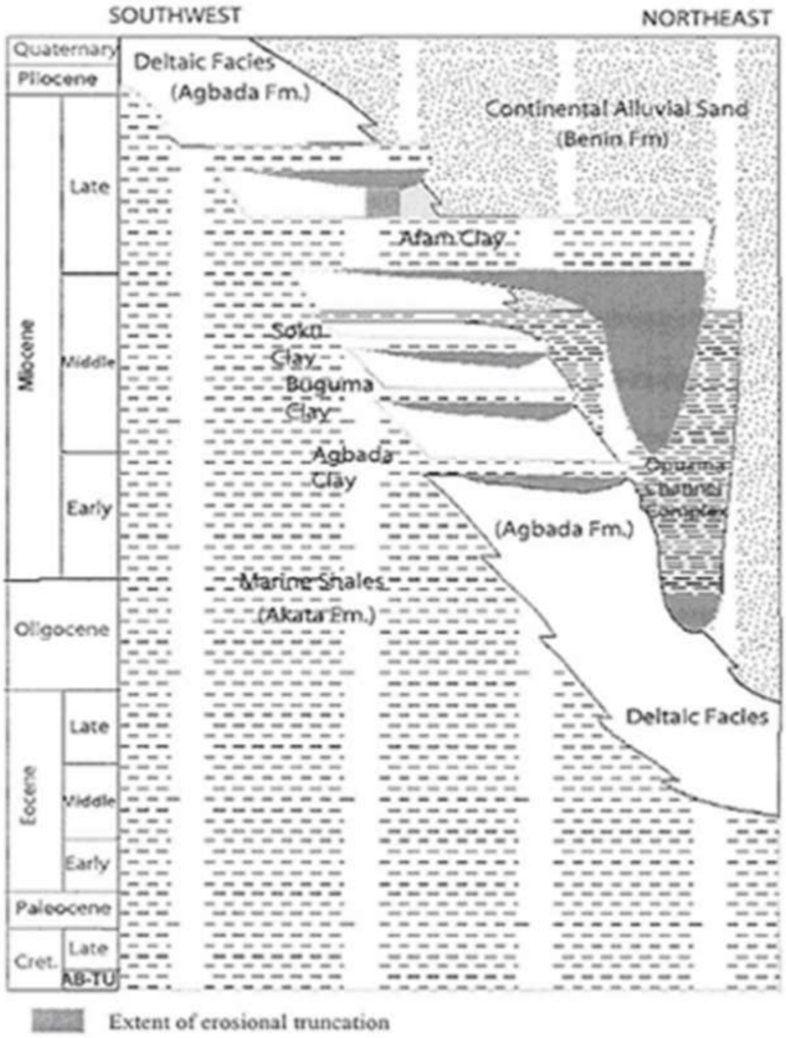


Figure 2.4: Stratigraphic column showing formations of the Niger Delta (Tuttle et al. 1999).

The following are the three formations found within the Niger Delta viz;

Akata Formation: Not far from the delta's base is where this is situated. Since turbidite sands made up the majority of the rock, this could indicate the presence of a reservoir at great depths. A thick coating of shale was also found in the rock, suggesting that it likely originated from a specific rock. Furthermore, the product contains trace levels of clay and silt. The ocean and this statement are connected in some way. It lies in the outer delta and is visible from land; its thickness varies between 0 and 6,000 meters. It rises out of the ground in the protruding delta. The water was supplemented with clays and organic materials from the ground when its oxygen and energy levels were low. The formation of this deposit in deep water places was triggered by this (Michele et al, 1999). Some estimates put the thickness of the delta's central structure at 7,000 meters (Doust and Omatsola, 1990). Geologists believe that while the Earth was in the Palaeocene and Holocene, it leaked due to the tremendous pressure. Today, the incident is being investigated by the appropriate authorities.

Agbada Formation: Sandstones, shales, and paralic siliciclastic are among the numerous rock types that comprise the Agbada Formation. The sequence's true deltaic component becomes apparent during agbada generation. Its thickness is around 3,700 meters. The lower, thicker shale rock unit is heavier because of its depth. It has a lot of shale and is largely composed of sand. It carries out its function as the system's central component. There are a lot of microfauna at the foot of the formation, but as you climb, you'll see fewer of them. From what we can see, the delta front appears to be depositing at a faster rate. Because they were large and appeared unsorted, the grains were believed to have originated in a river. Sedimentary growth faulting is associated with the bulk of the hydrocarbon resources. I suppose that's possible. The Agbada Formation is at the base of the deltaic zone. Investigations on the possible connections between the Ameki and Ogwashi-Asaba Formations, which date from the Eocene to the Oligocene, are under underway. It spans the southern Pliocene and the beginning of the Pliocene in the north. All of the surface features of the delta originate from the Recent. Although it may be almost four thousand meters thick in the delta's center, the delta's perimeter and the ocean provide a narrower profile. The quantity of hydrocarbons allows one to speculate about the duration between the Eocene and Pliocene epochs.

Benin Formation: Benin Formation, a huge formation that begins in the western Niger Delta and continues far beyond the modern-day coastline, reaches the ocean. Its distance from the current shore of the ocean is greater. You may observe shale intercalations surrounding the sandstone. The grainy, gravelly mixture contains little pieces of wood and streaks of lignite. Its shape could range from completely straight to almost spherical. This habitat is situated in the upper delta and likely covers the whole continent. The presence of numerous unique structural units in the formation is indicative of the varied shallow water depositional medium. Point bars, oxbow fills, backswamp deposits, channel fills, and natural levees are all examples. In contrast to the younger southern sector, the northern one is older, having formed during the Oligocene epoch. It encompasses the entire current period as well as the Miocene. Although it may differ based on your location, the thickness is usually more than 6,000 feet. Significant hydrocarbon reserves are not associated with the formation.

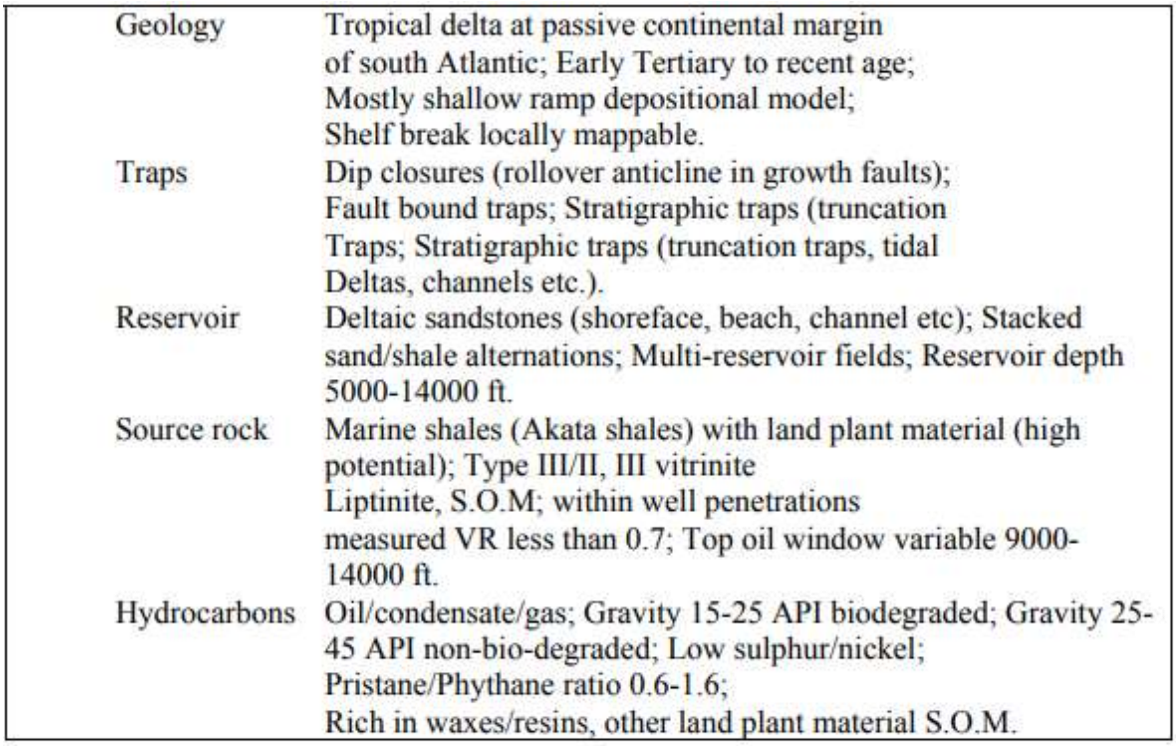
Table 2.1: Table of formations Niger Delta area, Nigeria. (Modified from Short and Stauble, 1967)

Subsurface			*Surface Outcrops*		
Youngest known Age		Oldest known Age	Youngest known Age		Oldest known Age
Recent	Benin Formation (Afam Clay member)	Oligocene	Plio/Pleistocene	Benin Formation	
Recent	Agbada Formation	Eocene	Miocene/Eocene	Ogwashi-Asaba Formation	Oligocene Eocene
				Ameki Formation	
Recent	Akata Formation	Eocene	Lower Eocene	Imo Shale Formation	Paleocene
Unknown			Paleocene	Nsukka formation	Maastrichtian
			Maastrichtian	Ajali Formation	Maastrichtian
			Campanian	Mamu Formation	Campanian
			Campanian/Maastrichtian	Nkporo Shale	Santonian
			Coniacian/Santonian	Agwu Shale	Turonian
			Turonian	Eze Aku Shale	Turonian
			Albian	Asu River Group	Albian

Rocks that are many thousand years old make up the formation (Doust and Omatsola, 1989). (Doust and Omatsola, 1989). In the early phases of the Niger Delta's deformation, the thickest shale deposits were identified along the axis between the Bida and Benue Troughs. As a result of the oil drilling in the Niger Delta, several deposits were created. The development of the structure along the continental slope has led more divaps to form in the water. Because they are submerged, these marine shales are under a lot of stress. Stacher thought of the Akata shales as rocks that were out in deep sea and resting flat (1995). (1995). The transition zone is simple to recognize because it drops rapidly into the Agbada Formation and features abundance of micas and plant bits (Doust and Omatsola, 1989). (Doust and Omatsola, 1989). Eleven kilometers northwest of Port Harcourt is the Agbada-02 Well, which signifies the completion of the Agbada Formation (Short and Stauble, 1967). Despite drilling to a depth of 9,500 feet, the rock could not be cracked (the base was defined as the top of the Akata Formation in Akata-01 well). Roughly 13,000 feet down lies a dense patch on it. Such a structure is ubiquitous in the clastic wedge of the Niger Delta. Approximately halfway between the southern Nigerian towns of Ogwashi and Asaba lies a cluster of rocks known as the Ogwashi-Asaba Formation (Doust and Omatsola, 1989). Successions can be anything from ten to one hundred feet long, as the bed thickness and grain size increase with time. In these successions, you can find sands, silts, and shale, among other kinds of rocks. It is believed that the strata were created as a result of river and delta conditions. The exact age of the formation is uncertain, while estimates place it anywhere from the Pleistocene and the Eocene. The Niger Delta, a clastic wedge, rests on the Benin Formation. It begins in the Onitsha region of northern Benin and continues beyond the coast (Short and Stauble, 1967). Data from the Elele-01 well, located 38 km northwest of Nigeria's Port Harcourt, formed the basis of this section (Short and Stauble, 1967). In the delta, close to the formation's apex, you may see the most recent surface datum. Its estimated depth of base is 4,600 feet. The 14th base is notable for having the youngest marine shale. In the lower portions of the delta and in the alluvial or elevated coastal plain regions, sand that did not originate from the sea was deposited during its creation (Doust and Omatsola, 1989). Although no living organism has been discovered to definitively confirm a date, it is believed that the formation began in the Oligocene or later (Short and Stauble, 1967). The structure thins down considerably as it approaches the edges of the basin and the shelves. Formations were classified by Short and Stauble (1967) according to the amounts of shale and sand discovered in subterranean well logs. Due to their reliance on well logs, which only partially penetrate type sections, these criteria are incompatible with the international stratigraphic code. They are hence stereotyped as being carefree and rule-breakers. Different formations' upper and lower portions are referred to by different geologists in the region. Since the freshwater sand begins here, this is the part of the Agbada Formation that usually comes up when the formation is mentioned. Although it is occasionally referred to as a "overpressured shale," the top layer of the Akata Formation is typically visible during drilling. According to their perspective, this is the typical way it is described. In contrast to the deep, turbidite sands of the Akata Formation, the Benin Formation sands feature thick argillaceous intercalations. Both types of sand are present in the Benin Formation.

According to Doust and Omatsola, this casts doubt on the validity of the formation definitions they proposed in 1989. Between the Agbada and Akata Formations, there was a thick layer of marine shale and a heavy coating of sand. So that their stratigraphic terminology might be employed, they proposed a less formal framework. Separating the Niger Delta deposits into large-scale lithostratigraphic sequences was proposed by Adesida and colleagues in 1977. This was achieved by the integration of biostratigraphy, stratigraphic surfaces from seismic section sequences, and log trends. The objective in constructing this was to facilitate better visibility of the surfaces of the successive layers. A petroleum system passes through the Agbada Formation in the Niger Delta's clastic wedge zone. On the other hand, most depobelts' southern sections tend to have a larger gas-to-oil ratio than their northern sections. Predicting the spread of hydrocarbons is challenging. Despite the complexity of the distribution of hydrocarbons, this remains true (Doust and Omatsola, 1989). According to Stacher, the stratigraphy of a handful of oil-rich bands in the Niger Delta region formed the basis of the hydrocarbon habitat theory (1995). This model was created using the sequence's stratigraphy as a starting point. Along with that, he briefly goes over the hydrocarbons, source rock, reservoir, and trap that make up the basin. On top of that, he briefly outlines these characteristics (Table 2.2). The gas-to-oil ratios discovered in reservoirs were discussed in works by Doust and Omatsola (1981), Ejedawe (1981), and Evamy et al (1981). (1978). This data is supplemented by the following sources: (1981). (1990). Port Harcourt is conveniently located near a number of lakes and reservoirs. Within the "oil-rich belts" that stretch from the northwest to the southeast, these storage places are distributed in various north-south patterns. The thickest sediment bands are typically located close to the oceanic and continental crustal boundaries, as shown in a 1999 study by Tuttle and colleagues. A change in the regulation of depositional or structural processes, an increase in the geothermal gradient, a change in the direction of deposition across a basin between depobelts, and other possible causes have been suggested by various authors as being associated with oil-rich belts. There are a lot of potential explanations for the alterations.

Table 2.2 Hydrocarbon habitat (Modified from Stacher, 1995)



Geology	Tropical delta at passive continental margin of south Atlantic; Early Tertiary to recent age; Mostly shallow ramp depositional model; Shelf break locally mappable.
Traps	Dip closures (rollover anticline in growth faults); Fault bound traps; Stratigraphic traps (truncation Traps; Stratigraphic traps (truncation traps, tidal Deltas, channels etc.).
Reservoir	Deltaic sandstones (shoreface, beach, channel etc); Stacked sand/shale alternations; Multi-reservoir fields; Reservoir depth 5000-14000 ft.
Source rock	Marine shales (Akata shales) with land plant material (high potential); Type III/II, III vitrinite Liptinite, S.O.M; within well penetrations measured VR less than 0.7; Top oil window variable 9000-14000 ft.
Hydrocarbons	Oil/condensate/gas; Gravity 15-25 API biodegraded; Gravity 25-45 API non-bio-degraded; Low sulphur/nickel; Pristane/Phythane ratio 0.6-1.6; Rich in waxes/resins, other land plant material S.O.M.

It is highly probable that the Niger Delta is the source of marine shale. Its form is determined by the Agbada and Akata forms. Subterranean Cretaceous shale is also present in the region. According to the results, the reservoir intervals of the Agbada Formation consist of shallow ramp settings composed of deposits from the transgression system tract and highstand (Evamy et al, 1978). The average depth of a reservoir is 45 feet or more, and some of them are over 150 feet deep. The height of some reservoirs exceeds 150 feet as well (Evamy et al, 1978). According to Kulke, the majority of reservoirs consist of coastal barrier bars that are subsequently fragmented by sands and point bars of distributary channels. Both of these components are situated along the shoreline (1995). Edwards and Santogrossi state that the majority of primary reservoirs are believed to consist of Miocene paralic sandstones (1990). Two Darcys of water may travel through 40% of these sandstones, indicating their porosity. Here you can find sandstone that is around 300 feet thick. Due to the expansion and contraction of faults, reservoirs can reach deeper levels (Weber and Daukoru, 1975). While river sandstones tend to be rougher, sandstones found in the delta front tend to be smoother. Reservoir units may contain grains of varying sizes. While point bar deposits can provide somewhat more precise results, grain sorting is typically considered the best method for working with barrier bar sandstones. According to Kulke, the majority of sandstones contain trace quantities of cement, both siliceous and argillaceous (1995). Almost all sandstones have this quality. The delta complex's periphery is where you're most likely to find reservoirs. Formations such as lowstand sand masses, deep channel sand, and turbidite sandstone deposits comprise these reservoirs (Beka and Oti, 1995). The Agbada Creation episode marked the beginning of syn-sedimentary deformation. As a result, structural and stratigraphic traps formed (Evamy et al., 1978; Stacher, 1995). (How Ohti and Beka conducted their study in 1995). The best places to find reservoirs in the Niger Delta complex were located when appropriate traps were set up along the delta's margins. The majority of the Agbada Formation is composed of seal rocks, which are found in the shales that make up the formation. Layers rich in shale run parallel to one another, forming vertical seals. Additionally, three distinct seal types have been identified: fault-induced reservoir sands, clay streaks along faults, and interbedded sealing units. Every one of these seals is special in its own way (Doust and Omatsola, 1990). The research of Doust and Omatsola was published in 1990. Severe erosion carved up the gorges in the Early and Middle Miocene epochs. Shale, which is included within them, serves as the upper seal for the delta's sides. At least portion of the vast seaside meadows are home to these seals (Doust and Omatsola, 1990).

METHODOLOGY

Datasets

The data provided includes ninety-five (95) ditch cuttings samples recovered from WELL-01 and WELL-02.

Method

The study described here is primarily concerned with the geochemical characterization and interpretation of depositional environment. The methodology was carried out on the following subject as outlined below:

- Sample collection: Ditch cuttings or core samples were collected from Well-1 at various depths.
- Sample preparation: The samples were crushed, ground, and powdered to a fine consistency.
- X-Ray Fluorescence (XRF) analysis: The powdered samples were analyzed using XRF to determine the elemental composition, including the oxides of Si, Ti, Al, Fe, SO3, Cl, Ca, Mg, Na, K, and Mn.
- Data analysis: The XRF data were analyzed to calculate the oxide composition, elemental ratios, and mineralogical composition.
- Statistical analysis: There is a possibility that statistical techniques, such as principal component analysis and correlation analysis, were utilized in order to recognize patterns and relationships within the data.
- Interpretation: In order to gain a better understanding of the sedimentary history and paleoenvironment of Well-1 and 2, the data were interpreted by taking into account sedimentary petrology, geochemistry, and depositional environment.

RESULTS AND INTERPRETATION

XRF Analysis

The results of the XRF analysis expressed the major and minor oxides as a percentage of the total weight. Both Well-1 and Well-2 have table 4.7 and table 4.8 that contain the results of the main oxide composition analysis.

Table 4.7: Major Oxide Composition (%) for Well-1

% Oxide Composition	**Well-1 6295-6310**	**Well-1 6445-6460**	**Well-1 6670-6685**	**Well-1 6895-6910**	**Well-1 7750-7765**	**Well-1 7840-7855**	**Well-1 7855-7870**	**Well-1 7900-7915**	**Well-1 7915-7330**	**Well-1 7930-7945**	**Well-1 7960-7975**	**Well-1 7975-7990**
SiO_2	59.04	51.92	59.2	70.62	59.52	59.85	54.6	53.04	53.33	53.93	52.63	59.59
TiO_2	2.12	2.39	2.65	0.993	2.43	2.26	2.32	2.96	2.4	2.44	2.67	3.07
Al_2O_3	15.18	14.31	14.9	13.5	14.29	13.95	15.1	14.89	15.08	15.1	15.05	15.14
Fe_2O_3	5.06	5.06	5.65	2.34	2.64	2.96	4.58	4.37	3.1	3.07	4.58	5.74
SO_3	4.56	3.57	Nd	Nd	3.62	3.81	3.09	3.16	4.29	4.22	5.3	Nd
Cl	Nd	2.24	Nd	2.06	1.29	1.37	1.16	1.6	1.18	1.07	1.17	Nd
CaO	2.34	6.63	2.92	3.71	2.56	3.55	3.67	4.23	3.98	2.85	2.67	2.23
MgO	0.47	0.43	0.62	0.23	0.49	0.42	0.52	0.74	0.6	0.49	0.52	0.55
Na_2O	0.061	0.065	0.584	0.031	0.062	0.036	0.048	0.031	0.05	0.98	0.994	0.08
K_2O	0.023	0.044	0.366	0.012	0.034	0.02	0.023	0.011	0.013	0.62	0.206	0.021
MnO	<0.001	<0.001	<.001	<0.001	<0.001	<0.001	0.042	0.042	0.03	0.02	<0.001	0.044
SiO_2/Al_2O_3	3.889	3.628	3.973	5.231	4.165	4.290	3.616	3.562	3.536	3.572	3.497	3.936

Fe_2O_3/ K_2O	220.000	115.000	15.437	195.000	77.647	148.000	199.130	397.273	238.462	4.952	22.233	273.333
TiO_2/Al_2O	0.140	0.167	0.178	0.074	0.170	0.162	0.154	0.199	0.159	0.162	0.177	0.203

Table 4.8: Major Oxide Composition (%) for Well-2

% Oxide Composition	**Well-2 7405-7420**	**Well-2 7750-7765**	**Well-2 7765-7780**	**Well-2 7855-7870**	**Well-2 7870-7885**	**Well-2 7885-7900**	**Well-2 7900-7915**	**Well-2 7930-7945**	**Well-2 7975-7990**
SiO_2	54.3	55.65	55.24	51.9	54.03	51.86	43.01	46.08	21.02
TiO_2	2.96	2.43	3.32	2.54	0.87	2.14	2.2	2.07	1.98
Al_2O_3	15.01	16.04	14.51	13.28	13.44	15.03	10.51	14.68	10.33
Fe_2O_3	6.13	4.74	5.13	2.66	3.8	2.75	3.39	2.25	7.542
SO_3	Nd	Nd	Nd	4.84	Nd	6.4	19	4	11
Cl	Nd	Nd	1.99	Nd	2.37	2.25	1.45	1.23	1.08
CaO	5.2	3.38	3.16	4.2	8.79	5.14	2.91	9.79	28.6
MgO	0.774	0.47	0.8	0.81	2.8	1.1	0.48	2.81	0.2
Na_2O	0.069	0.053	0.07	0.93	1.37	0.065	0.79	1.64	0.83
K_2O	0.035	0.031	0.032	0.67	0.65	0.02	0.61	0.73	0.29
MnO	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.03	0.005
SiO_2/ Al_2O_3	3.618	3.469	3.807	3.908	4.020	3.450	4.092	3.139	2.035
Fe_2O_3/ K_2O	175.14	152.90	160.31	3.97	5.85	137.50	5.56	3.08	26.01
TiO_2/Al_2O	0.197	0.151	0.229	0.191	0.065	0.142	0.209	0.141	0.192

DISCUSSION

It is possible that this approach to XRF analysis, applied to ditch cutting samples from Wells 1 and 2, might provide light on the formations' mineral composition. Different silicates, primarily quartz and clays, are likely present due to the presence of the two primary oxides, SiO2 and Al2O3. Sedimentary rocks are composed primarily of tiny quartz and clay grains, therefore this makes sense from a geological perspective (Tucker, 2001).

To distinguish between shale rocks, which are rich in clay and low in ratios, and sandstones, which are rich in quartz and clay, one must look at the SiO2/Al2O3 ratio, which is silicon dioxide to aluminum dioxide. The samples that were examined typically had SiO2 to Al2O3 ratios ranging from 3.5 to 4. The area is composed of feldspathic and wacke sandstones, commonly referred to as "shaly sands," according to the data collected (Boggs, 2009). Feldspars and rock fragments constitute a significant portion of the mineral composition, as indicated by the comparatively low ratios. This demonstrates that the current methods of sorting and mineralogical maturity are inadequate. The fact that the ratios are significantly lower than normal is also emphasized. Mechanical weathering and rapid deposition significantly impacted the sedimentary environment (Blatt, Middleton, & Murray, 1980).

Another indicator of mineral stability is the manganese dioxide to potassium hydroxide ratio. There were a lot of less stable, iron oxide-rich rock-forming minerals discovered. These differed from potassium-rich stable mineral groupings. This is proven by the fact that the ratios increased in both Well-1 and Well-2 (Fe2O3). This is the main distinction between lithic arenites and greywackes. There are few solid minerals, such as quartz and K-feldspars, and a lot of rock fragments in lithocarenites. Greywackes and lithic arenites display this characteristic (Doust & Omatsola, 1990). The findings of this investigation indicate that the sediments were derived from very young source rocks that had minimal chemical weathering. This is the conclusion that can be drawn from the evidence that is now available.

In addition to supporting the findings of the sediment provenance inquiry, the titanium dioxide to aluminum dioxide ratios provide more evidence. A significantly higher-than-average ratio of titanium dioxide to aluminum dioxide was present. This points to the samples' likely origin in metamorphosed or mafic igneous rocks. Titanium dioxide levels in mafic source rocks are known to be greater, and the sample ratios corroborate this (TiO2). The lack of movement or weathering is demonstrated by this. Furthermore, the presence of feldspars and other rock pieces indicative of a mafic source indicates that the rock in question likely originated from a volcano or a pluton. This indicates that a mafic process was responsible for the rock's formation.

Results from XRF analyses of Wells 1 and 2 samples reveal that silicates, particularly quartz and clays, constitute the bulk of the sedimentary makeup. Using SiO2/Al2O3, you can differentiate between many types of sandstones, including feldspathic and wacke sandstones. This is because of the development level and mineral composition of the organism. The presence of minerals with lower stability in forming rocks is indicated by the Fe2O3 to

K2O ratios. The presence of these minerals in lithic arenites and greywackes provides evidence of their existence. The ratios of titanium dioxide to aluminum dioxide indicate that the sediments most likely originated from a metamorphic or mafic igneous source. We now know more about the creation and evolution of sedimentary formations because to the findings of these investigations. The intricacy of the environment in which the rocks that created the sediments were revealed by these findings, together with their physical properties.

CONCLUSION

By analyzing ditch cutting samples from Wells 1 and 2, XRF can provide a clearer picture of the sediments' primary oxide composition. When atmospheric concentrations of SiO2 and Al2O3 are increased, silicates, primarily quartz and clays, are produced. Feldspathic and wacke sandstones indicate a relatively youthful mineral composition. The estimated SiO2/Al2O3 ratios, typically ranging from 3.5 to 4, provide evidence of this. Pettijohn et al. published the findings in 1987. With such high Fe2O3 to K2O ratios in both wells, it was evident that the minerals remained stable during the run. For instance, compared to minerals found in other rock types, those in lithic arenites and greywackes are not very stable. This indicates that rock fragments, rather than solid minerals like K-feldspar and quartz, are produced by the sediment source (Ingersoll and Sutherland, 1970). The sediments might have originated from igneous rocks that underwent metamorphism or were formed by magma because of the concentrations of titanium dioxide and aluminum dioxide found in them. Rocks from particular lithologies have higher ratios of these elements, which is why this phenomenon occurs (McLennan, 1989). The geochemical investigation uncovered numerous locations, including rocks formed by igneous and metamorphic processes, sedimentary depositional sources, and more. At the location where these sediments were created, there was a great deal of tectonic activity. The distance traveled was likely not very far due to the low ratio of SiO2 to Al2O3.

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